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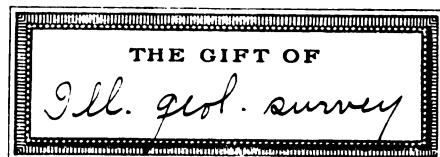
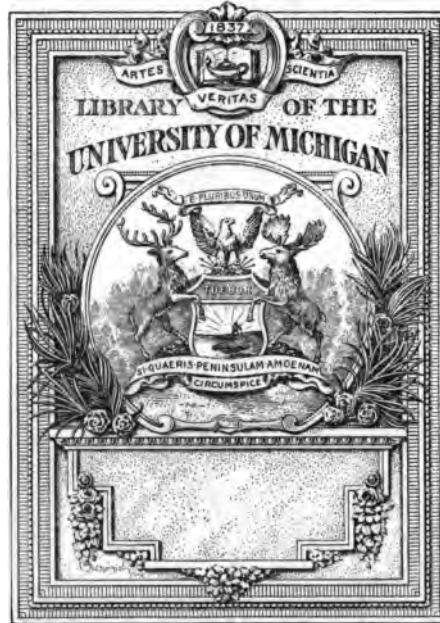
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ILLINOIS
STATE GEOLOGICAL SURVEY

BULLETIN NO. 6



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ILLINOIS
STATE GEOLOGICAL SURVEY.

BULLETIN No. 6.

The Geological Map of Illinois
[Second Edition]

BY

STUART WELLER



Urbana
University of Illinois
1907



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Phillips Bros., State Printers.
1907.

State Geological Commission.

GOVERNOR C. S. DENEEN, *Chairman.*

PROFESSOR T. C. CHAMBERLIN, *Vice Chairman.*

PRESIDENT EDMUND J. JAMES, *Secretary.*

H. FOSTER BAIN, *Director.*

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ILLINOIS
STATE GEOLOGICAL SURVEY.

BULLETIN No. 6.

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LETTER OF TRANSMITTAL.

STATE GEOLOGICAL SURVEY,
UNIVERSITY OF ILLINOIS,
URBANA, ILL., Nov. 5, 1907.

To Governor C. S. Deneen, Chairman, and Members of the Geological Commission:

I respectfully submit herewith manuscript for a second edition of Dr. Stuart Weller's geological map of Illinois with the recommendation that it be printed as bulletin 6 of the present series.

In June, 1906, in transmitting the manuscript for the first edition I made the following statement:

"It is a well founded practice to begin new work with a careful digest of material already on hand and available. With this thought in mind Dr. Weller was instructed soon after his appointment as geologist of this survey, to compile in the form of a geological map such existing information regarding the formations of the State as might be available. It was believed that such a compilation would throw into sharp relief the areas in which accurate and inaccurate surveys already had been made, and would permit of economical direction of future work. The map herewith transmitted is the result. It will be seen that it is very greatly generalized, and the need of additional detailed work in many portions of the State is evident. The present map will, however, serve as an excellent base upon which to make corrections as the present survey progresses. Since it will be impossible to cover the entire State with detailed maps for some years, and since no geological map of the State is now available for general distribution, it is recommended that a small edition be printed for the use of the field parties of the survey, the schools of the State and the persons interested in its mineral resources.

"In using this map it should be remembered that it is merely a summary of the best information available at the time of publication. There are probably many gross errors, which it will be the purpose of the present survey to correct. The map, as Dr. Weller indicates, is based largely on that published some years ago by Dr. Worthen, and the conditions under which the Worthen survey was made were not such as to permit of the modern degree of detail and accuracy. Geology

is a progressive science, and in the years since the older survey was discontinued, study of the geology of the adjacent states, together with the development of more refined methods of research, render it possible not only to make a more accurate, but a more useful map than formerly was expected. It is proposed from time to time to issue new editions of the present map, incorporating in each such additional data as may be available at the time of publication and suitable to its scale."

At the time it was not anticipated that a new edition would be so promptly demanded, but early in the present year the small number of copies of the first remaining, and the large number of corrections which it was possible to make were deemed sufficient to warrant a new edition. The map was accordingly revised in February and printed and delivered in June. Owing to various causes the sending forward of the text has been delayed till the present. This is fortunate in that it permits a somewhat fuller revision than would have been possible and it illustrates the rapidity with which development is taking place that the map itself is somewhat out of date. In the text Dr. Weller discusses briefly the various formations and the changes in their delimitation and definition which now seem necessary.

On the present map, as before, the shipping coal mines of the State are indicated on the basis of the Peabody atlas prepared by Mr. A. Bement and courteously placed at our disposal by Mr. Francis S. Peabody. These locations have been revised in places by our own field men as well as by the State mine inspectors to whom we are therefore under obligations. The lead, zinc and fluorspar producing localities are indicated as are also the producing oil pools. The developments of the present season have greatly extended the latter and many of the smaller pools shown separately on this map are now known to be connected. The scattered occurrences of oil and gas in the State are not indicated. It is to be hoped that before a new edition of the map is called for some of these may be in regular production.

It is hoped in future editions of this map to show not only revisions of the geology but the location of more and more of the mineral industries of the State as the data in our possession becomes sufficiently complete.

Very respectfully,

H. FOSTER BAIN,
Director.

THE GEOLOGICAL MAP OF ILLINOIS.

[Second Edition]

BY STUART WELLER.

INTRODUCTION.

Purpose of a Geological Survey—The position of the natural economic products which exist within the crust of the earth in any region, is determined either by reason of the physical conditions present at the time of formation of the rocks in which they are contained, or by reason of subsequent dynamic changes. Thus beds of coal, limestone, sandstone, clay, etc., which may be termed primary economic products, are where they are in the earth's crust by reason of certain peculiar local conditions which have been present in that locality at some past time in the history of the earth; the present position of most metallic mineral deposits, on the other hand, and also of petroleum, is usually determined first, by certain structural features within the earth's crust, such as faults and folds, which have influenced the secondary segregation of these deposits; and, second, by the peculiar character and texture of the rocks which are affected by the folding and faulting.

It is the task of the geologist to investigate the ancient history of the earth, to observe the peculiar characters of the rock strata, and to determine, if possible, the conditions under which they have been formed; also to investigate the changes through which the strata have passed since their deposition. All these observations are recorded graphically upon the geological maps which the geologist constructs. These maps may be of little or of great value from an economic or a historical point of view, dependent wholly upon the accuracy and detail with which the facts of the earth's history are recorded upon them.

Sources of Material—The accompanying geological map of Illinois makes no pretense of entire accuracy, or of properly differentiating in all cases the geological formations of the State. This second edition of the map has been compiled from such published and unpublished data as are available, including such information as has been gathered during the first season's field work of the survey. The text accompanying the map, however, has been written after the close of the second

year's work in the field, so that it is somewhat in advance of the corrections upon the map itself. The map is presented, in part at least, for the purpose of showing the inadequacy of our present knowledge of the geology of the State in relation to its great natural resources, as well as for the purpose of assisting to point out certain economic and stratigraphic problems which it is desirable that the State Geological Survey should investigate, some of which lines of research have already been initiated. In order to be of the greatest service from an economic or a historical point of view, a geologic map must be constructed with sufficient detail to show with much accuracy the geographic distribution of the various lithological and historical units, and their relations to the topographic features of the region.

The columnar sections which accompany the map have been compiled from the recorded observations of the earlier geological survey, and from such additional data as have been found available. These sections are by no means final, and their imperfections are fully recognized. With the continued prosecution of the work of the present survey additional data will certainly be secured which will permit the construction of much more accurate sections. In all cases the maximum reported thickness of the formations has been plotted in the columnar sections.

The sources of the data used in the preparation of the present map have been various. The map published by A. H. Worthen in 1875, and distributed with volume VI of the reports of the geological survey of Illinois has been the primary base used. This map itself was compiled from a series of county reports made by Worthen and his associates, which taken together constituted a reconnaissance survey of the State. The complete map is exceedingly generalized, and the boundaries of the formations recognized were only intended to be relatively accurate. In fact it is frequently difficult to locate exact boundaries because no lines were drawn between the colored areas, and the overlapping colors often cover a belt several miles in width on the scale of the map used.

The map published by Frank Leverett in connection with his report on "The Water Resources of Illinois"** has been a second source of information. This is on a much smaller scale than the original Worthen map. In prosecuting his studies of the drift deposits, Leverett visited all parts of the State and modified the mapping of some of the formations in various localities.

The geologic section across the State prepared by Prof. J. A. Udden in 1892 for the World's Fair commissioners† has been useful in the preparation of the present map, and has been especially valuable in the construction of the columnar section for the northern portion of the State. This section extends across the State eastward from Rock Island through LaSalle to the Indiana state line, and crosses some or all of the geological formations of each of the Paleozoic periods represented in the State. A paper by O. H. Hershey‡ has afforded data

* U. S. Geol. Surv., 17th Annual Report, part 2, pp. 701-849; map, pl. 112.

† Report Illinois Board World's Fair Com., pp. 117-151.

‡ Am. Geol., vol. 14, pp. 169-179 (1894).

in regard to an area of St. Peters sandstone along Elk Horn creek, in western Ogle county. In Whiteside county various modifications based upon unpublished field observations of Mr. G. C. Matson have been incorporated. Perhaps the most notable change from the old Worthen map is to be found in the northwestern portion of Jo Daviess county, in an area which has recently been mapped by the United States Geological Survey in connection with the investigations of the lead and zinc deposits of the Upper Mississippi valley.* A comparison of this small accurately mapped area with the adjoining districts shows, perhaps better than anything else, the eminent desirability of a new and reliable map of the State. In the southern portion of the State modifications have also been incorporated on the basis of recent investigations, by the United States Geological Survey, of the fluor-spar deposits of Illinois.†

In this second edition of the map two notable changes have been made in addition to the alterations based upon recent field observations. These are the addition of the areas of the alluvial bottom lands along the more important rivers of the State and the omission of the line separating the Lower and the Upper Coal Measures. In the first edition of the map this latter line was drawn directly from the Worthen map, but experience has shown that it was in general somewhat arbitrary and of slight utility in interpreting the geology of the State.

In the following discussion of the various units represented upon the map here published, an attempt will be made especially to point out some of the stratigraphic problems whose investigation is desirable.

The geological formations of the State, exclusive of the surficial or Pleistocene formations, range in age from the lower Ordovician to the Tertiary. No deposits of Cambrian age, the most ancient period of geological history whose life is abundantly known, are exposed as the surface rock in the State, although they doubtless underlie the younger formations. Although the surface formations range from the Ordovician to the Tertiary in age, not every period in the series is represented; the entire interval from the top of the Carboniferous to the Tertiary being unrepresented by rock strata except for some Cretaceous beds which probably are present with the Tertiary in the southern part of the State. Furthermore, within the Paleozoic series itself, there are several interruptions or unconformities, each of which represents a time hiatus of greater or less length during which a part or the whole of the area of the State was above sea level and received no aqueous sediments.

LINES OF DEFORMATION.

While in general the rocks of the State are flat-lying or have imperceptible dips, they are not absolutely horizontal. Taken as a whole the eastern interior coal field, which occupies most of the State, is a great, shallow, synclinal basin with dips towards the center from all sides. These dips can be measured only in feet per mile. There are,

* U. S. Geol. Surv., Bull. No. 294.

† U. S. Geol. Surv., Bull. No. 255.

however, a few lines along which the dips are reversed, so that there are certain poorly defined anticlinal areas. These have not yet been carefully worked out, though the more important ones are noted below.

In the northwestern portion of the State, an anticlinal axis crosses into Illinois in Carroll county, near Savannah, but is best developed in Jackson county, Iowa. An important deformation line also crosses the Illinois-Wisconsin boundary in Stephenson county, and continues with a direction of about 23° east of south, crossing Rock river at Grand Detour, and the Illinois between LaSalle and Utica. This line seems to be a simple anticlinal fold with the southwestern limb much the steeper. It brings small areas of the Lower Magnesian limestone and larger areas of the St. Peter sandstone to the surface in Ogle county, and again in LaSalle county. This fold seems to continue southeastwardly beyond the Illinois river, but the rock surface of this portion of the State is so deeply buried by drift that it is not easy to follow such a line of deformation. The occurrence of areas of older rocks in the northern portion of the State, not in a continuous area of outcrop, but in a series of outcrops, isolated one from the other, suggests the possibility of a series of folds transverse to the major northwest-southeast axis, the outcropping areas being at the intersections of the axes.

Another line of deformation crosses the Mississippi river in southern Calhoun county with a direction of about 5° south of east. It crosses the Illinois river a few miles above its mouth, passing into Jersey county, but soon strikes the Mississippi again by reason of the eastward bending of that stream, and following the course of the river is soon lost. Where the line crosses the Mississippi river from Missouri into Calhoun county, it is marked by a fault having a throw of about 720 feet, the St. Peter sandstone of the Cap au Grés bluff being brought to the surface by the upthrow to the north, the strata on the southern side of the fault line being Mississippian limestones. One and a half miles east of the river the throw of the fault is reduced to 280 feet, and in the Illinois river bluff in Jersey county the fault has apparently been transformed into a monoclinal fold, although the line is again marked by faulting before it disappears in the Mississippi river.

Still another line of deformation is recognized in the Mississippi river bluffs of southern St. Clair county. It is an anticlinal fold whose northeastern limb has a very gentle dip, while the southwestern limb pitches steeply with a dip of 30° or more. The axis of this fold has a direction of about 20° east of north, but can not be traced any considerable distance because of the deep mantle of drift present in that portion of the State away from the Mississippi river bluffs. Two other anticlines similar to the one just described, but with their axes trending more easterly and with much slighter dips, are exhibited in the Mississippi river bluffs in Monroe county. The first of these is at Valmeyer, where the Kimmswick limestone of Ordovician age forms the axis of the fold, the second being nearly opposite Renault station with beds of Keokuk age forming the axis of the fold.

In the extreme southern portion of the State, two anticlinal axes are recognized, which pass from the Mississippi river on the west to

the Ohio river on the east. The first of these passes from near the mouth of the Big Muddy river with a direction of about 7° south of east, crossing the Ohio above Elizabethtown. At the west Devonian and Silurian rocks are brought to the surface, while eastwardly the Mississippian limestones form the axis of the anticline, with a small area of Devonian black shale in Hardin county. The conglomeratic Mansfield sandstone at the base of the Pennsylvanian, upon the northern limb of this anticline, stands up as a prominent ridge about ten miles in average width, the crest being from 700 to 800 feet above sea level, or about 300 feet above the adjoining regions to the north and south of it. In Pope and Hardin counties Bain* has mapped several faults, more or less transverse to this axis, which were doubtless formed at the time of the anticlinal folding, and more recent studies show that similar faulting is abundantly developed entirely across the State upon the southern limb of this anticline. The continuation of the same area, across the Ohio river in Kentucky, is also much faulted as has been shown by Ulrich†.

The southernmost deformation axis which has been recognized, passes from the vicinity of Thebes, with a direction of about 7° south of east, to Grand Chain on the Ohio river. At Thebes this elevation brings the rocks of Trenton age to the surface, where they form, in the Mississippi river, a reef which at times is dangerous to navigation. Eastwardly this axis is buried beneath the Tertiary formations, but at Grand Chain on the Ohio river a reef similar to that in the Mississippi is recognized.

Further detailed work will doubtless bring to light other lines of deformation, as well as give us far more accurate knowledge of these here recognized. In the earlier interpretations of the stratigraphy of the State, the faults were recognized in only a few instances. This type of deformation, however, is far more prevalent than would be indicated by the present mapping, especially in the southern part of the State, and its recognition, in connection with future work of the survey will doubtless frequently alter older interpretations. The occurrence of petroleum and natural gas at various localities in the State is probably associated with anticlinal folds in the strata, which are usually so deeply buried beneath the superficial deposits as to be recognized with difficulty or not at all from the surface outcrops of the hard rocks.

GEOLOGICAL FORMATIONS.

CAMBRIAN.

Potsdam Sandstone—This formation belongs to the most ancient of the great periods of the earth's history, which are represented by sediments in the crust of the earth, bearing an abundance of organic remains. This period is known as the Cambrian, and the Potsdam sandstone, so-called, in the upper Mississippi valley region, represents

* U. S. Geol. Surv., Bull. No. 255, pl. 2.

† U. S. Geol. Surv., Prof. Pap. No. 26, pl. 2.

some part of the middle and upper Cambrian. The formation is nowhere exposed at the surface in Illinois, but it has been penetrated in several deep wells in the northern portion of the State, the greatest thickness observed in this manner being about 1,000 feet, but nowhere has the bottom of the formation been reached. This sandstone extends northward beneath the younger formations, being exposed as the surface formation over considerable areas in Wisconsin; it doubtless continues southward underlying the entire State of Illinois, although it is not improbable that its lithologic characters change more or less. Where the formation is best known in Wisconsin, it is most commonly a yellow sandstone. Because of its large lateral extent and its porous character, it constitutes a reservoir from which an abundant supply of water can be obtained.

ORDOVICIAN.

Lower Magnesian Limestone—This formation comprises the most ancient beds exposed in the State, and in its surface outcrop is more limited than any other division recognized upon the map. The largest exposed area is along the Illinois river in the neighborhood of Utica, in LaSalle county, where the formation outcrops for about two miles in the bluff on the north side of the river. Other small areas are known in LaSalle county along the Little Vermilion river and Tomahawk creek north of LaSalle. Outside of LaSalle county the formation is known only in western Ogle county where it outcrops for several hundred yards along the south bank of Elk Horn creek,* and in Calhoun county where a few feet are exposed at low water beneath the St. Peter sandstone at Cap au Grés bluff.

Although this formation is so limited in the area of its surface outcrop, it is by no means an unimportant geological formation in Illinois. Like the subjacent Potsdam sandstone it doubtless underlies the entire area of the State. The deep wells in northern Illinois which have penetrated the Potsdam sandstone have all passed through the Lower Magnesian limestone, and the formation can be best studied in the section across northern Illinois prepared by Udden. Observations of the deep well data along the line of this section show that the formation increases regularly in thickness from east to west, being approximately 450 feet at the Indiana state line, while at Rock Island a thickness of 811 feet is recorded.

St. Peter Sandstone—The surface outcrops of the St. Peter sandstone are confined almost entirely to the northern portion of the State, where it is usually a soft, light colored, friable sandstone. Two principal areas are recognized, in the first of which the formation is well exposed along the Illinois river from east of LaSalle to the mouth of Fox river, and is continued up the valley of that stream for some distance, with a small detached area still higher up the same valley in the edge of Kendall county; in the same area the formation extends for some distance up the valleys of the Vermilion and the Little Vermilion rivers which empty into the Illinois at LaSalle. The second

* Hershey, Am. Geol., vol. 14, p. 170.

large area lies to the northwest of the one already mentioned, in Lee and Ogle counties, in the valley of the Rock river from a short distance above Dixon to beyond Oregon, and up the valleys of the chief tributaries of this stream in the area. Besides in these larger areas this formation is the surface rock in a small area in the western part of Ogle county, which was first mapped and described by Hershey.* According to Leverett† this formation also extends down the valleys of the Rock and Pecatonica rivers from the Wisconsin state line as far as the cities of Rockford and Freeport. In these valley areas, however, although the formation is apparently the underlying rock, it is so deeply covered by glacial deposits that no outcrops of it are anywhere exposed; neither of these valley areas exceed one or two miles in width. Besides these areas of the St. Peter sandstone in the northern part of the State, there is only one recognized exposure of the formation in Illinois, and that a small one in Calhoun county on the bank of the Mississippi river where this formation forms the southern extremity of the Cap au Grés bluff. To the north from this exposure the formation dips beneath the younger strata, and to the south it is cut off by a fault which crosses the Mississippi at this point. The maximum thickness of this formation in the State, as shown in deep well records, is 275 feet, although near Utica, where its best exposure may be seen, its thickness is apparently about 150 feet.

Like the two preceding formations the St. Peter sandstone has a much greater distribution than is indicated by its limited surface exposures. The formation as exposed in Calhoun county, is, without doubt, continuous beneath the younger strata with the beds exposed in northern Illinois, and it is not improbable that the formation underlies the entire State. The formation is eminently porous and is freely penetrated by the underground waters, and is of great economic importance as a reservoir from which an abundance of water may be secured by means of deep wells.

Trenton-Galena Formation—In future geologic mapping of the State, this unit will undoubtedly be divided. As now mapped the division includes all the calcareous dolomitic beds between the St. Peter sandstone below and the usually shaly or arenaceous Cincinnati beds above. In the northern portion of the State these strata have a thickness of from 300 to 440 feet, as shown in deep well records which have penetrated the St. Peter sandstone; in the central portion of the State in Calhoun and Jersey counties, about 250 feet have been recognized; in southern Illinois the entire thickness of the sediments is nowhere exposed, less than 100 feet of the uppermost beds being known.

In the northwestern portion of the State the full thickness of the sediments of this interval are not well shown in the surface outcrops, only the upper or Galena dolomite member being well exposed. These sediments, however, are doubtless similar to or identical with those of the adjoining region in southern Wisconsin where two distinct formations are recognized, the Platteville limestone below and the

* Am. Geol., vol. 14, pp. 169-179.

† Private communication.

Galena dolomite above.* The Platteville limestone is for the most part non-magnesian, and is generally a fine grained, even textured, gray or bluish limestone, having a conchoidal fracture. Much of it is thin bedded with shale partings, and it attains a thickness of 65 feet. The earlier geologists in the Mississippi valley correlated this formation with the Trenton limestone of the New York section, but it is now known to be older than the typical Trenton. The Galena dolomite is now usually correlated exactly with the New York Trenton, although it is very different from that formation lithologically. It is in general a more or less crystalline, heavy bedded, buff colored dolomite, some portions of which carry chert. At the base there are a few feet of thin bedded limestones, and at the summit of the formation the dolomite is thin bedded through a thickness of 30 feet. The entire thickness of the formation approximates 240 feet. To the east these formations undergo more or less profound lithologic changes, but the beds may be divided throughout into two divisions which may be correlated with the Platteville limestone and the Galena dolomite.

In the west central portion of the State, where strata of this age are exposed in Calhoun and Jersey counties, the lithologic characters of these formations are very different from those in the more northern region. Three formations are recognized which occupy the same interval as the Platteville and Galena formations, these are the Joachim dolomite below, followed by the Plattin limestone, with the Kimmswick limestone at the summit.† The Joachim is a more or less thin bedded magnesian limestone or dolomite, somewhat variable in its lithologic characters, but usually of a buff color and somewhat granular or gritty in texture. It has a thickness of approximately 75 feet. The Plattin is a more pure, drab or gray limestone, more or less thin bedded, usually fine-grained and even textured, often exhibiting conchoidal fracture. Some parts of the formation resemble more or less closely the lithologic characters of the Platteville limestone. It attains a thickness of about 100 feet. The Kimmswick is a highly crystalline, nearly white or flesh colored limestone, usually about 50 feet in thickness and highly fossiliferous. Instead of the conspicuous dolomitic limestones of the more northern part of the State, purer limestones are here the rule, and, furthermore, although they are doubtless contemporaneous in age, the fossil faunas which characterize the strata in the northern and central portions of the State are not entirely identical. The two regions represent what is known to the geologist as two distinct geologic provinces, and it is important both economically and historically, to determine the true relations of these provinces, their boundaries, the different physical conditions which have existed in them and the reasons for such differences. In the solution of such problems as this the application of paleontology to geology or applied paleontology is of the utmost importance, for the reason that the life which has existed or which still exists in any given region, is one of the most delicate indices of the physical conditions which there obtain. The study of such problems as this, concerning the ancient

* Zinc and Lead Deposits of the Upper Mississippi Valley. by H. Foster Bain, U. S. Geol. Surv., Bull. No. 294, pp. 19-30.

† Ill. State Geol. Surv., Bull. No. 4, p. 222.

geologic provinces of the interior of North America, has only just begun, and the investigations of the survey should contribute data of great value towards the solution of these general problems.

In the southern portion of the State a small exposure of Kimmswick limestone underlain by the Plattin occurs in the Mississippi river bluffs at Valmeyer, Monroe county, and a somewhat larger area extends north and south of Thebes in Alexander county. In both of these areas the Kimmswick limestone possesses the same characteristics, both lithologic and faunal, as in Calhoun county. Besides the known exposures, however, these formations have a wide distribution beneath the younger rocks, perhaps underlying the entire State, aside from the areas where older rocks are exposed at the surface.

Cincinnatian Formation—The beds of this age vary greatly in lithologic character in the different parts of the State where they are exposed, and seem to be limited to the uppermost or Richmond division of the formation as it is more completely developed in the region lying east of the Cincinnati arch. In the northwestern part of the State the formation is represented by the Maquoketa formation which is, in the main, a bed of blue or green clay shale with occasional bands of dolomite and limestone. In this region it attains a thickness of from 140 to 175 feet.

In Calhoun county the formation is a green shale which becomes somewhat dolomitic towards the base, but is reduced in thickness to about 75 feet. In Monroe county the formation is similar in character and in thickness to that in Calhoun county, but is underlain by a limestone bed one or two feet in thickness which bears a typical Richmond fauna. The base of the shale formation is characterized through a thickness nowhere greater than two or three feet, and frequently much less, from the northern boundary of the State to Monroe county, by a peculiar fauna constituted largely of diminutive pelecypods, of which the species *Clidophorus neglectus* and *Ctenodonta fecunda* are the most conspicuous.

In the northeastern portion of the State the Cincinnatian beds are well shown in the banks of the Kankakee river above Wilmington, where they are more calcareous than along the Mississippi, and contain an abundant fauna of the Richmond type.

In the southern part of the State, at Thebes, in Alexander county, the Cincinnatian is represented by two divisions, a lower sandstone member, the Thebes sandstone, about 75 feet in thickness, which is a dense buff or brown sandstone below, passing upward into thin bedded sandstones or arenaceous shales. The upper member is the Cape Girardeau limestone, about 40 feet in thickness, which is a thin bedded, fine grained, compact, dark or almost black limestone having a conchoidal fracture. The fauna of this limestone suggests that it is younger than any of the other Cincinnatian beds in the State.

In connection with the future investigation of the Cincinnatian beds in Illinois, one highly important stratigraphic problem must be constantly kept in mind. Recent paleontologic investigations have shown that at least a large part, or perhaps all of the beds of Cincinnatian

age in the Mississippi valley region west of the Cincinnati anticline, correspond paleontologically with the uppermost or Richmond division only, of the Cincinnati as it is developed in the typical region in the Ohio valley; the Lorraine and Utica divisions being entirely absent. This fact suggests that west of the Cincinnati anticline there is a widespread pre-Richmond unconformity. Such an unconformity and stratigraphic break has not been generally recognized in the Mississippi valley, but a post-Richmond unconformity has been quite generally assumed, although with no very definite field evidence. In Calhoun county, and in Jefferson county, Missouri, directly opposite the Monroe county, Illinois, exposure of the Kimmwick limestone, a pre-Richmond unconformity can be clearly recognized,* but in the northern portion of the State the physical break has not been satisfactorily observed. In the Cape Girardeau limestone in southern Illinois and Missouri, the Richmond faunas seem to blend with the overlying Silurian faunas, a fact which, in the absence of any definite post-Richmond stratigraphic unconformity, suggests that this generally assumed stratigraphic break may be without sufficient foundation. This problem cannot be solved in Illinois alone, but the investigations in this State can contribute important data towards its solution. The problem is of far-reaching importance in historical geology, in that it may ultimately involve the question as to the proper position of the boundary line between the Ordovician and Silurian systems.

The solution of the problem of the Richmond in the northern portion of the State, is made more difficult by reason of the shaly nature of the beds, the contacts, especially the most critical one between this formation and the underlying beds, usually being too poorly exposed to admit of close stratigraphic study.

SILURIAN.

Niagaran Limestones—The rocks of Silurian age in Illinois have always been referred to in the literature of the State as the "Niagara limestone." This formation, however, does not correspond exactly with the Niagara, or as it is now called, the Lockport limestone of the New York section, but probably represents a much longer time interval. These rocks occur in four more or less distinct areas in the State, and in these different regions they present more or less variable lithologic characteristics.

In northeastern Illinois the Niagaran limestone occupies a great area extending from central Iroquois county to the Wisconsin state line; in this region the beds attain a thickness of from 300 to 388 feet, and consist, for the most part, of more or less massive dolomites of a bluish or buff color, such as are exhibited along the Chicago drainage canal and along the Desplaines river valley to Joliet and beyond. In the lower portion of this series, however, there are certain beds of more nearly pure limestone, and also some shaly beds, but neither the stratigraphic succession nor the faunal succession have yet been accurately worked out. In the northwestern part of the State the Silurian occupies considerable areas in the valley of the Mississippi river

* Ill. State Geol. Surv., Bull. No. 4, p. 223; also Jour. Geol., vol. 15, pp. 519-525.

and its tributaries, where the beds are similar to those further east in their dolomitic character, and are usually of a buff color. In Jersey and Calhoun counties these rocks again come to the surface in the valleys of the Mississippi and Illinois rivers, north of the Cap au Grés fault, with a thickness of from 50 to 120 feet; here again the beds are dolomitic, usually massive and of a buff color, and are especially well exposed at and near Grafton. In the southern portion of the State, in Jackson, Union and Alexander counties, there is a considerable area indicated as Silurian on the accompanying map which needs further careful investigation. In the old reports these beds were referred to as the "Lower Helderberg limestone," and it is possible that locally some small portion of the formation may be of that age. Definite Helderbergian faunas, however, have not been observed in Illinois, although they do occur in Missouri, in the Mississippi river bluffs opposite Grand Tower, and also still further north in Perry county. The formation in this area is entirely different from that in the north, and consists of exceedingly cherty limestones, the chert being present in horizontal bands a few inches in thickness, alternating with about equally thick limestone bands. South of Thebes, in Alexander county, a conspicuous part and perhaps the whole of the formation there present, is a hard, pink limestone. North of Thebes the formation thickens and becomes more blue or gray in color, although the pink limestone bed is more or less persistent in that direction, occupying a position towards the top of the formation. The maximum thickness of these beds in this area is about 250 feet.

The stratigraphic relations of the Silurian to the underlying Cincinnati beds should be carefully studied for its bearing on the Richmond problem already mentioned, and the distribution of the fossil faunas within the formation should be investigated for its bearing upon the correlation of the formation with the Silurian beds in other portions of the country, and for the purpose of determining the relations of the geologic provinces of Silurian time in the Mississippi valley. In the Silurian as in the Ordovician, there was apparently a distinct northern and southern province in the interior of North America, although little is known as to the relations between the provinces. In one respect there is a striking parallelism between the provinces during these two periods, and that is in the presence of highly dolomitic beds in the northern, and more calcareous beds in the southern province. In both cases, accompanying the differences in the lithologic characters of the sediments, there are distinct differences in the fossil faunas. Comparatively little is known at the present time in regard to the conditions which have produced the extensive dolomitic formations of the earth's crust, and because of the great development of such formations in the northern portion of Illinois, and their great economic value, it will properly come within the scope of the survey to investigate in considerable detail the conditions of their formation.

Like all of the preceding formations in the State, the Silurian rocks are probably continuous beneath the younger formations except along their northern boundary, where the Coal Measures overlap to some extent.

DEVONIAN.

Strata of Devonian age form the surface rock at three widely separated regions in the State. The first of these is in Rock Island county, where the rocks have a maximum thickness of about 150 feet, although only about 75 feet are exposed, the total depth of the formation being known from deep well records. These strata are of middle and upper Devonian age, are mostly limestones and frequently contain numerous fossils which show their relationship to be with that geologic province of Devonian time which extended off to the northwest into Iowa and beyond. The second Devonian area is in Calhoun and Jersey counties, where scarcely more than ten feet of limestone of this age are present; the faunas which they contain show that these beds also belong to the northwestern or Iowan province.

The third area is in the southern portion of the State, in Jackson, Union and Alexander counties,* the beds are chiefly limestones and sandstones, and the contained fossil faunas of middle Devonian age show that they belong to a totally different geological province than the beds farther north, their relationship being with the Devonian faunas to the eastward in the Ohio valley and even New York.* In this southern area there is also a considerable series of lower Devonian strata of totally different age from any of the strata further north.

The lowest Devonian beds in this southern area are of Helderbergian age, and are evidently a northward extension of the Helderbergian strata of Tennessee. In the old reports of the Illinois Survey Worthen referred to an important formation of interbedded cherts and limestone in these southwestern counties, some 250 feet in maximum thickness, as the "Lower Helderberg," but this formation is quite certainly of Silurian age, at least for the most part. True Helderberg fossils have been found at but few isolated localities, and as yet nowhere in Illinois, in certain beds at the summit of the formation, but the true relations of these genuine Helderberg beds to the subjacent Silurian formation, is not yet wholly understood. Typical Niagaran fossils, however, have been found at several points within the so-called "Lower Helderberg" of Worthen.

The lowest Devonian formation of notable thickness and with a wide geographic distribution in the area, is the Clear Creek formation. This formation reaches a thickness of about 300 feet and is largely a decomposed chert where it is exposed at the surface, frequently so pure and white, and so fine of texture, that it is mined extensively and, after being prepared as a powdered silica, is used for various purposes in the arts. In the more deep seated portions of this formation, and in those situations where it has been less subjected to the influence of surface waters, it contains a considerable amount of limestone, being in fact a highly siliceous or cherty limestone. This formation has been correlated by Worthen with the Oriskany of the New York section, and its fauna does suggest its Oriskany age in several particulars although some of its fossils resemble species of the Onondaga limestone,

* The map of this portion of the State is incorrect in not representing a large enough Devonian area in Union county. The east line of the Devonian outcrops should be located nearly as far east as Jonesboro.

† Weller, Jour. Geol., vol. 5, pp. 625-635.

a formation which is immediately superjacent to the Oriskany in the general section.

Following the Clear Creek formation in Union county is a yellow, more or less friable sandstone about 10 feet in thickness, which was referred to the Oriskany sandstone by Worthen. This sandstone is not infrequently abundantly fossiliferous, but the fossils in no way suggest the Oriskany, being a true Onondaga fauna.

Above this sandstone is a series of limestones 160 feet or more in thickness, often free from chert and usually of a brown color. This formation is well exposed at the "Devil's Bake Oven" and in the "Devil's Back Bone" above Grand Tower in Jackson county, where many of the beds are abundantly fossiliferous, and again in the Mississippi river bluffs northwest of Jonesboro in Union county. The faunas of the Bake Oven section have been studied by Weller and have been shown to be of Onondaga and Hamilton age.* This formation is certainly contemporaneous, in part at least, with the Devonian formations further north in Calhoun and Rock Island counties, but the character of the fossil faunas show that it was deposited in a basin wholly cut off from that in which the more northern beds were laid down, probably by an area of dry land. This southern Devonian basin was connected directly with the Devonian area in the Ohio valley and with the New York basin.

The youngest Devonian strata in the southwestern counties is the "Devonian Black Shale," which frequently exhibits the typical characteristics of this wide-spread formation of the Ohio valley region. In Union county it attains a thickness of 60 feet. In southern Union county the black shale seems to be replaced by a peculiar, green, siliceous shale, but the true relations of this bed to the black shale are not yet fully understood.

Besides these three chief Devonian areas, the remnants of formerly existing Devonian formations have been noticed near Chicago,† preserved in joint cracks of the Silurian limestone, sometimes as much as 20 feet below the upper surface of the Silurian formations. These joint fillings are dark colored and arenaceous, and their age is indicated by the fossils, chiefly fish teeth, which they contain. The most notable of these Devonian remnants occurs at Elmhurst, but a similar crack filled with Devonian materials has been observed in the quarry at Lyons. The faunal relationships of these fish teeth near Chicago are with the Devonian faunas of Iowa and also with those from near Milwaukee, Wisconsin.

The deep well data recorded by Udden in his geologic section‡ indicate the presence, through a considerable area west of LaSalle, of a calcareous and shaly formation varying from 40 to 100 feet in thickness lying between the Niagara limestone and the Coal Measures. This is probably Devonian in age, although no fossils are known. The extent of this area in a north and south direction is uncertain.

* Jour. Geol., vol. 5, pp. 625-635.

† Weller, Jour. Geol., vol. 7, pp. 483-488.

‡ Report Illinois Board World's Fair Com., pp. 117-151.

In the southeastern portion of the State, in Hardin county, a small area of Devonian black shale is known, which has been recently mapped in connection with the work of the United States Geological Survey in that portion of the State.*

Unlike the preceding formations, the Devonian rocks do not extend continuously throughout the State beneath the younger formations. In the first place it is not certain that the Devonian sea covered the entire area of the State, at least contemporaneously, and in the second place, a considerable portion of the State was elevated above sea level at the close of Devonian time, and those Devonian rocks which had been formed were eroded wholly or in part before the transgression of the sea brought about the formation of younger sediments. The remnants of sediments of Devonian age found in the joint cracks of the Niagara limestone near Chicago, indicate the former greater extension of formations of this age, as also do the Devonian beds recognized in the deep well sections west of LaSalle. The Devonian area of the Rock Island region is probably continuous with the strata of the same age in Calhoun and Jersey counties, but this northern and central area is probably not connected beneath the younger formations with the Devonian area in the southern portion of the State.

CARBONIFEROUS.

MISSISSIPPIAN.

General Classification—The area colored as Mississippian on the accompanying map, extends nearly the entire distance from Mercer to Jackson counties along the Mississippi river, and across the southern portion of the State from Union to Hardin counties. This unit is a very complex one, and in any future mapping five or more distinct divisions must necessarily be recognized and mapped. In its present condition the map is of little value, either from the economic or the historical standpoint. In the Illinois reports published under the direction of Worthen, these Mississippian or "Lower Carboniferous" formations as they were called, were divided into five groups, as follows, from the lowest to the highest: 1. Kinderhook; 2. Burlington; 3. Keokuk; 4. St. Louis; 5. Chester.

This older classification represents the general relations of the Mississippian formations. It is not sufficiently complete, however, for the purposes of modern geological studies, and Ulrich† has recently suggested a more critical classification of the beds which is represented in the following table:

* U. S. Geol. Survey, Bull. No. 255.

† U. S. Geol. Surv., Prof. Pap. No. 36, p. 24.

Ulrich's Classification of the Mississippian.

MISSISSIPPAN		WAVERLYAN.		TENNESSEAN.		CHESTER GROUP.			
Kinderhook Grp.	Osage Group.	Meramec Group.		Kaskaskia limestone.	Birdsville formation.....	Tribune limestone.....	Cypress sandstone.....	Aux Vases sandstone of Keyes. Probably also Big Clifty sandstone of Norwood.	
			Ste. Genevieve limestone		Ohara limestone.....	Rosiclar sandstone.....	Fredonia oolitic limestone		Two upper members referred to as lower Chester by Worthen and Englemann. Entire formation referred to as St. Louis by Norwood.
			St. Louis limestone.....						St. Louis limestone of most authors, but not of Englemann, Shumard and Swallow, who do not include two lower formations in the St. Louis limestone. The two upper formations equal, respectively, the Mitchell limestone and the Bedford oolitic limestone of recent Indiana reports.
			Spergen limestone.....						
			Warsaw formation						
			Tullahoma formation.....					Keokuk limestone.....	
								Burlington limestone....	Harrodsburg limestone (typical) and Knobstone of Indiana.
									Various formations of the Kinderhook group..

These divisions recognized by Ulrich have been used as a basis for mapping done by the United States Geological Survey in the fluorspar district of western Kentucky and southern Illinois, but it must be somewhat modified to represent the true relations of the Mississippian beds in Illinois. The two major divisions made by Ulrich, the Waverlyan and the Tennessean are of but doubtful utility, in Illinois at least; if they are to be retained at all the dividing line between them, as also the line between the Osage group, the upper division of the Waverlyan, and the Meramec group, the lower division of the Tennessean, should be shifted so as to include the Warsaw formation in the Osage. The four secondary groups would better be considered as the primary divisions of the series in Illinois but with certain modifications of their boundaries. However the lesser formation units are the really important elements for first consideration, and the grouping of these may be deferred for the time being. Eight of these formations will be briefly considered here, although one or two of these units must eventually be subdivided still further. These divisions are, from the older to the younger, 1, Kinderhook; 2, Burlington; 3, Keokuk-Warsaw; 4, Salem (=Spergen Limestone); 5, St. Louis; 6, Ste. Genevieve; 7, Cypress; 8, Chester or Kaskaskia.

Kinderhook—The Kinderhook beds comprise various more or less local formations, which may be either limestones, sandstones or shales. The Kinderhook as a group may be recognized from as far north as Burlington, Iowa, to Union county at the south, but none of the component, local formations have any such wide distribution. The formation as a whole varies in thickness from 25 feet to 200 feet.

Burlington Limestone—This formation has its typical development at Burlington, Iowa, but it is clearly differentiated as far south as Union county, although it is not continuously exposed through that entire distance. It is usually a highly crystalline, nearly white, crinoidal limestone, with a maximum thickness of about 200 feet, but in the northern part of the area of its occurrence there are frequently brownish beds in the lower portion of the formation. Locally the formation is quite pure limestone, but more often it contains a considerable amount of chert in horizontal layers from two to four inches in thickness, or in lenticular masses arranged in horizontal bands. At times the aggregate thickness of the included chert bands equals or is greater than the aggregate thickness of the interbedded limestone.

Keokuk-Warsaw Limestone and Shale—In its typical expression at Keokuk, Iowa, and at Warsaw, Illinois, this formation differs from the subjacent Burlington limestone, in its usually darker color, often having a bluish or grayish color, and in the shaly partings which frequently separate the thicker ledges of limestone, sometimes developing into shale beds several feet in thickness. In this district the formation is comparatively free from chert, but the beds immediately subjacent to the Keokuk proper, forming a sort of transition zone from the Burlington to the Keokuk, are highly siliceous and have been called the Montrose cherts in some of the Iowa reports. At the summit of the Keokuk proper at Warsaw, there is a conspicuous geode bed which may be recognized as far south as Jersey county. The total thickness of the Keokuk proper is about 125 feet.

The typical Warsaw beds, about 40 feet in thickness, lie above the geode horizon. The strata are variable in character and comprise beds of dolomite, limestone and shale, but the sedimentation from the Keokuk to the Warsaw is apparently continuous.

In following these two formations to the south, the two horizons, Keokuk and Warsaw are not so sharply differentiated as in their typical area, although the two formations considered as a single unit can be clearly recognized as far south as Union county, and there may usually be distinguished a lower more calcareous and an upper more shaly zone, which correspond roughly with the Keokuk and the Warsaw members. It is also difficult in the central and southern portion of the area covered by this formation, to sharply differentiate between the Keokuk and the subjacent Burlington limestone, since the cherty beds of the Burlington continue up to the shaly beds which are presumably Warsaw, although the lithologic characters of both the limestone and the chert change towards the summit of the series.

*Salem Limestone**—This formation is one of the best defined in the whole Mississippian series in Illinois. It has frequently been confused

* Ulrich has used the name Spergen for this limestone, but the name Salem for the same formation, used by the Indiana Survey, has priority.

with the Warsaw formation by the earlier writers, although it is entirely different in both lithologic and faunal characters, and has until lately, been included in the St. Louis limestone in Illinois and elsewhere. The formation is often abundantly fossiliferous, and many of its fossils have been described by various authors, but have almost invariably been referred to either the Warsaw or the St. Louis formation. In fact, a large proportion of all the species of fossils which have been described in our literature as from the St. Louis limestone, are really from the Salem limestone.

In its more typical exposures, in the central and southern portion of its area of distribution, the formation is for the most part a nearly pure limestone of a light color, often nearly white. It frequently contains an abundance of fossil bryozoans belonging largely to the Fenestellidae, which often appear as white, uncrystalline, calcium carbonate imbedded in the more crystalline surrounding matrix. Some beds are more or less oolitic. Many of the beds exhibit a type of weathering, due to frost action, not usually seen in the other Mississippian limestones, the more or less vertical faces of the outcrops scaling off at right angles to the bedding, in irregular, rather thin flakes of the size of a mans hand or somewhat larger. This type of weathering is more commonly present on the outcrops of the whiter and purer and oolitic beds of the limestone. Some minor magnesian beds occur in the formation, and such beds have been mined in Madison county and in St. Clair county, years ago, for the manufacture of a natural hydraulic cement.

The Salem limestone can be clearly recognized from Hancock county on the north to Union county on the south. It has its greatest thickness in the southern half of its area of outcrop, where it attains approximately, a thickness of 125 feet. In Madison county its thickness is about 100 feet, but at Warsaw, in Hancock county, not more than 10 feet of more or less impure limestone can be included in the formation. Towards the north where the formation grows thinner, it does not exhibit its typical characteristics as further south, and it rests unconformably upon the underlying Warsaw beds; it may be identified, however, by the fossils which it contains.

St. Louis Limestone—The St. Louis limestone is characterized by the exceedingly variable character of its beds. It is for the most part a limestone of a blue or gray color, being distinctly darker, as a usual thing, than the subjacent Salem limestone. The strata are thick or thin bedded, they may be hard, dense and fine grained limestone, or they may be more or less crystalline; shaly limestones and even beds of shale are sometimes present, and some beds in some portions of the State, are more or less brecciated or conglomeratic. A notable characteristic of the formation is the presence of fine grained, dense, limestone beds having a conchoidal fracture and almost the texture of lithographic stone. Occasionally beds of arenaceous limestone are met with. The amount of chert contained in the formation is exceedingly variable. In the river bluffs north of Alton but little chert

occurs, but in other regions cherty zones are more or less conspicuous, but nowhere is it so abundantly cherty as are some parts of the Burlington and Keokuk limestones.

Fossils are usually rare in the St. Louis limestone, although certain beds are occasionally met with where they are abundant. The fossil coral *Lithostrotion canadense* is usually considered as a most characteristic member of the fauna, but this coral does not occur universally throughout the formation. Great thicknesses of the limestone, over large areas can sometimes be examined without the detection of a single individual of this coral, while at other times it is met with as scattered colonies or as conspicuous coral beds made up of great numbers of large and small colonies. Several bryozoans are highly characteristic of the formation and these sometimes occur abundantly in certain shaly beds, and at two localities in the southern portion of the State conspicuous cephalopod beds have been observed. A few brachiopods are scattered through the formation, sometimes being rare and again being abundant, and an occasional crinoid is met with. The great majority of all the fossils which have been referred to the St. Louis limestone in the literature do not occur in the formation at all, but in the subjacent Salem limestone.

The thickness of the formation is greatest to the south where it reaches 250 feet or more, it thins to the north and is only about 10 feet thick at Warsaw, in Hancock county.

Ste. Genevieve Limestone—The Ste. Genevieve limestone has usually not been distinguished from the St. Louis, and in its lithologic characters, especially in its variability, it closely resembles the St. Louis. In it, however, oolitic beds which are absent in the St. Louis, appear, and it is, perhaps, less cherty than the St. Louis. The main distinction is a faunal one, there being a recurrence of the types of life which were abundant in the Salem, but absent from the St. Louis. The same recurrence of conditions which brought about the deposition of oolitic limestone, were probably responsible for the recurrence of the life similar to that of the Salem limestone.

In Hardin county three members of the Ste. Genevieve limestone have been recognized by Ulrich,* the Fredonia member below, the Rosiclare sandstone member in the middle, and the O'Hara member, consisting of limestone and shale, at the top. In the Mississippi river section the O'Hara member is not developed, at least in Illinois, but a sandstone member probably to be correlated with the Rosiclare sandstone, occurs in Monroe county and also at Alton. It is nowhere possible to draw a sharp line between the St. Louis limestone and the base of the Fredonia member of the Ste. Genevieve, which can be followed over any considerable area in stratigraphic work, but the line between the Ste. Genevieve and the superjacent Cypress sandstone is a distinct stratigraphic break marked by an erosion unconformity.

Cypress Sandstone—The line dividing the Cypress sandstone from the subjacent beds separates the lower Mississippian limestones with a total thickness of 1,000 feet or more, from the upper Mississippian

* U. S. Geol. Surv., Prof. Pap. No. 36.

beds which are dominantly sandstones. This upper arenaceous series constitutes the "Chester Group" of the literature, the Cypress sandstone being the so-called "Lower member of the Chester." The formation is quite uniform in character, a moderately fine grained, yellowish-brown sandstone, rather heavy bedded in its lower portion, becoming more thinly bedded above. Its thickness varies from 80 feet or less to 150 feet or more. In the Mississippi river section the formation is well exposed and forms abrupt bluffs at Modoc in Randolph county, and for some distance above and below this point. Between this formation and the subjacent Ste. Genevieve limestone a distinct erosion unconformity is exhibited between Modoc and Prairie du Rocher. This outcrop in the bluffs is continued as a belt several miles in width, diagonally across Randolph and Monroe counties into the southern edge of St. Clair county, where it passes beneath the Pennsylvanian strata. The formation does not occur anywhere in the State north of this area, but in the south it covers large areas in the belt across Union, Johnson, Pope and Hardin counties, although it is often difficult to differentiate it from some of the higher Chester sandstones because of the similarity in lithologic characters, and the large amount of faulting in that district. Nowhere in the formation have fossils been found.

Chester "Group"—From most of the literature on the subject one gains the impression that the Chester is dominantly a limestone formation, but in working over the area occupied by the beds in the field, one is impressed with the fact that it is in large part sandstone. Nowhere in that part of Illinois occupied by these beds, is the limestone element in the formation the most conspicuous feature, except along the Mississippi river bluffs above Chester, from that city to the point where the Cypress sandstone outcrop begins. It is probable that where the limestone has its greatest development, not more than one-third of the total thickness is calcareous, and over a large part of the area the thickness of the limestones probably does not exceed one-fifth of the entire thickness.

The best region in which to study the succession of beds in the Chester, is in the Mississippi river bluff above and below the city of Chester. This section shows an alternation of chiefly calcareous and chiefly arenaceous formations, there being three conspicuous limestone beds and three sandstones. The limestones are frequently interbedded with calcareous shales, and the sandstones frequently become arenaceous shales or at times clay shales.

The lowest member of the "group," above the Cypress sandstone, is a limestone and shale formation attaining a maximum thickness of approximately 250 feet at and above Chester. In its lower portion it includes considerable beds of calcareous and clay shales, a bed of variegated red and blue shale being commonly present near the base. In the upper part of this member is a great limestone ledge about 100 feet in thickness, with occasional thin shaly partings, which furnishes the quarry rock at the Southern Illinois Penitentiary, at Menard. The great mass of the fauna of the "Chester group" in Illinois, has been described from this lower, calcareous member of the formation as a whole.

Ulrich has made two divisions of the Chester above the Cypress sandstone, the Tribune limestone below and the Birdsville beds above, but the lower calcareous member of the Chester in the Mississippi river section does not correspond with the Tribune formation of Ulrich. His Tribune limestone with its recurrent Salem limestone fauna, is only a minor bed included in the midst of the lower calcareous member of the series of beds comprising the Chester as a whole.

The second member of the "group" is a sandstone or shale, the shale being most conspicuous in the more northern part of the area, while to the south it is almost wholly a sandstone similar to the Cypress in character, but usually thinner bedded and not infrequently more or less of an arenaceous shale. This division attains a thickness of about 80 feet. The third member is again a limestone which is apparently more impure than most of the beds of the lower division. It is much less fossiliferous than the lower division and the fossils are such as to give it definite faunal characters which can be recognized over wide areas. Its thickness near Chester is about 60 feet. The fourth member is again a sandstone similar to the earlier sandstone beds, and attains a thickness of 65 feet. The fifth member is a limestone similar to limestone No. 2, in lithologic characters, and is usually almost or quite unfossiliferous. Its thickness is about 35 feet. Following the third limestone is another great sandstone member 100 feet or more in thickness, which is finely exposed back of the village of Rockwood in Randolph county.

It seems to be altogether probable that these three limestone beds of the Chester "Group" can be differentiated and mapped throughout the faulted area in the southern part of the State, and by means of them the structure worked out in much detail. In the final work upon these beds it will probably be found to be expedient to distinguish each of these six members of the Chester by distinct formation names, just as the Cypress sandstone is now distinguished.

PENNSYLVANIAN.

No geologic formation in Illinois contains greater economic resources than the Pennsylvanian or Coal Measures. Here are to be found the enormous coal resources which exceed all other mineral products of the State combined, besides great deposits of clay, usually in the form of shales, and less important beds of limestone and sandstone. All of these products are being utilized to a greater or less extent at the present time, Illinois being the third State in the Union in the production of coal, but their future development is destined to be vastly more extensive. The investigations of these formations by the Geological Survey, and their accurate mapping will undoubtedly prove to be of inestimable value to the citizens of the State.

In the present edition of the geological map of the State, the arbitrary line dividing the Pennsylvanian into two series, the "Lower" and the "Upper" coal measures, has been dropped. The former geological Survey recognized sixteen different coal seams in the entire series, ranging in thickness from one to nineteen feet, and separated

by greater or less thicknesses of shales, sandstone and limestone, the aggregate thickness of all the beds being 1,200 feet or more. It has usually been assumed that these coal seams were continuous throughout the area of the State occupied by the Pennsylvanian strata, except where the higher ones may have been removed by erosion. More recent investigations in neighboring States, notably in Indiana and Iowa, have shown that the coal seams in these States are not continuous beds over great areas, but that they are local, more or less lenticular bodies, having a more or less limited geographic extension. It is of course possible that the conditions are somewhat different in Illinois, and that the seams are more nearly continuous, this being the more central portion of the great Mississippi valley coal field as a whole. It is, however, a matter of great importance, in the development of the coals, to determine with certainty the actual facts in regard to their distribution. These facts, in so far as they can be determined by a study of the natural outcrops of the formations, and of the sections shown in shafts and drill holes, will be recorded on the new geological maps being constructed by the survey. These maps will be made in much greater detail than the one here presented, and many smaller formations will doubtless be recognized.

The observations already made by the members of the survey upon the Pennsylvanian strata, seem to indicate that the formation of coal began at an earlier period in the southern portion of the State, so that the so-called oldest or No. 1 coal in that section is older, perhaps very much older than the so-called No. 1 coal in the northern part of the area. Some of the higher beds, however, seem to be more widespread in their distribution, and may perhaps extend over a large portion of the coal fields within the State.*

In the southern part of the State the basal formation of the Pennsylvania is a sandstone which sometimes resembles the subjacent upper sandstone member of the Chester "group," but it is usually a more heavily bedded formation, and is more or less conglomeratic, the included pebbles being of rather small size and of a white quartz material. This formation is the "mill-stone grit" of the older reports, and includes the Mansfield sandstone of the Indiana geologists. Its thickness is approximately 200 feet. In the central and northern portion of the State the basal sandstone of the Pennsylvania is not conglomeratic, and is probably much younger than the Mansfield sandstone of the south. The Pennsylvania beds everywhere rest unconformably upon the subjacent formations.

One of the important horizons to be studied and accurately mapped in connection with the investigations of the Pennsylvanian by the survey, is a limestone known locally as the "Carlinville" or "Shoal Creek" limestone, which was supposed by Worthen to have wide geographic distribution and to occupy about the middle position in the entire coal measures or Pennsylvanian series. It was this formation which was used by him as the dividing line between the "lower" and the "upper" Coal Measures. If it can be shown that this is actually a continuous

* David White, Ill. State Geol. Surv., Bull. No. 4, pp. 201-203.

limestone formation which can be traced through a considerable portion of the Pennsylvanian area of the State, it will be of great value as a reference horizon to be used in mapping the overlying and underlying strata of coal, shales, sandstones and limestones.

PERMIAN.

No Permian rocks have been indicated upon the accompanying map, although undoubted vertebrate fossils of Permian age have been known from Vermilion county for many years. These interesting fossils which were first studied by Cope and later by Case,* have all been collected in a small area only a few rods in extent. The strata containing these fossils, however, have not been observed in place. Recent investigation of the locality, with extensive and exhaustive excavation, has shown that the "bone bed" so far as it is known, occurs only in strata which have been extensively displaced by land slides. The bed doubtless still exists somewhere in the immediate neighborhood, but the region is so heavily drift covered that it is hopeless to expect to find it again unless it be stumbled upon accidentally in some well excavation.

CRETACEOUS.

In the text accompanying the first edition of this map, it was stated that no Cretaceous strata, certainly known as such, are exposed anywhere in the State. Since that bulletin was printed a map covering the extreme southern portion of the State has been published by Glenn,† in which considerable areas in Pulaski and Massac counties, and a small strip in Pope county, are colored as Cretaceous, and the beds indicated are correlated with the Ripley formation of Mississippi. Heretofore all these beds so indicated within the State of Illinois, have been considered as Tertiary. These strata have nowhere afforded fossils indicative of their age, and fossil shells have not been found in them. A few fossil leaves are known to occur, but they have not been subjected to critical study. The beds are all more or less unconsolidated sands and clays of non-marine origin, and according to Glenn they may be traced continuously from southern Illinois across Kentucky and Tennessee into the typical marine Ripley beds of northern Mississippi. It is not improbable that these observations and conclusions are correct, but it has not seemed best to indicate this Cretaceous area on the present edition of the Illinois map, but to wait until all the evidence can be critically examined, especially the evidence which may be afforded by the fossil plants. Furthermore a Tertiary conglomerate overlies these beds and forms a more or less continuous covering throughout the area.

These sediments, whether they be Tertiary or Cretaceous in age, lie unconformably upon Paleozoic formations ranging from Ordovician to Mississippian in age; they consist of stratified sands and clays, some of the latter of which contain more or less lignite. At one point in Pulaski county a bed of glauconitic sand is associated with these strata.

* Jour. Geol., vol. 8, pp. 698-729.

† U. S. Geol. Surv., Wat. Sup. and Irr. Pap., No. 164, pl. 1.

TERTIARY.

If the sands and clays mentioned above are really Cretaceous in age, as seems to be the case, then the Tertiary shown on the map should be somewhat restricted. Near Caledonia landing and extending some distance north toward Grand Chain are certain clays, green sands and lignitic material believed by Glenn to represent the Porters Creek or flatwoods and the Lagrange or Lignitic formations of the south. To the west these pass quickly under the alluvial deposits of the Cache river bottoms and are succeeded by a ferruginous conglomerate with siliceous pebbles, or unconsolidated gravels of similar age which have been correlated with the Lafayette; a widespread formation of the southern States of Pliocene age. The Lafayette occurs more or less continuously over the embayment area in Alexander, Pulaski, Massac and Pope counties, occupying the higher ground.

North of the more or less continuous area of this formation, there are present upon the summits of some of the highest hills in Union county, and eastward in Gallatin county, a capping of ferruginous conglomerate similar to that further south, which marks a further extension of the same formation. Still further north in southern Calhoun county the Lafayette gravels occur on top of the divide between the Mississippi and Illinois rivers, resting unconformably upon the Paleozoic rocks, and buried beneath the loess.*

Worthen has also reported the presence in Hancock county at one or two localities, of a similar ferruginous conglomerate at the base of the drift, which may be a still further northward extension of the same formation.

Besides these occurrences of conglomerates and gravels mentioned above, certain fossils have sometimes been met with in the drift deposits of the northern portion of the State, which have sometimes been interpreted as indicating the presence of isolated, drift covered areas of Tertiary or Cretaceous strata in the Mississippi valley as far north as Henderson county. These fossils are probably all of Cretaceous age and are doubtless not of local origin, but have been transported to the place where they have been found, from the Cretaceous regions of the northwest.

PLEISTOCENE†.

Throughout the greater portion of the State the surface is more or less deeply covered with glacial deposits of Pleistocene age, which add greatly to the difficulty of interpreting the stratigraphy of the older underlying rocks. In the northwestern portion of the State is a driftless area comprising the greater portion of JoDaviess county, with portions of Stevenson and Carroll counties. Another small driftless area occurs in southern Calhoun county, and in southern Illinois the drift does not extend south of the conspicuous ridge which crosses

* Geol. Surv. Ill., Bull. No. 4, p. 231.

† For a fuller consideration of the Pleistocene of Illinois, see "Water Resources of Illinois," by Frank Leverett, U. S. Geol. Surv., 17th Ann. Rep., p. 706; also "Illinois Glacial Lobe," by Frank Leverett, U. S. Geol. Surv., Monog. No. 38.

the State from near Grand Tower to a point north of Elizabethtown. These Pleistocene deposits are variable in their lithologic characters, consisting of unstratified glacial till, stratified sand and gravel deposits, loess and alluvium. In southern Illinois, to about the latitude of St. Louis, the drift deposits are usually scarcely thirty feet in thickness and have not obscured the underlying rock surface sufficiently to have greatly changed the principal preglacial lines of drainage, but north of this area the drift is much thicker, sometimes exceeding 150 feet, so that with the exception of the bluffs along the larger streams the underlying rock surface is usually completely obscured. The average thickness of the drift for the entire glaciated portion of the State is about 75 feet.

IGNEOUS ROCKS.

The presence of igneous rocks in Illinois has been recognized only recently, and so far as known they do not occur outside of the southeastern portion of the State. The occurrence of these rocks is in the form of dikes which have been intruded into the Mississippian and Pennsylvanian formations. Bain has mapped several of these dikes in Pope and Hardin counties;* where they are greatly altered, and so far as can be determined, they fall into groups, mica-peridotites and lamprophyres, the latter group including the majority of the specimens. The position of these dikes, so far as they are known, has been indicated upon the accompanying map, although it has been necessary to exaggerate them considerably in order to show them at all on a map of this scale.

Besides the dikes which have been shown on the map, DeWolf has observed, in connection with his work on the coals, the presence of similar intrusives at one or two points in Saline county, where they penetrate the Pennsylvanian formations. These have only been observed in some of the mines, and where they have penetrated the seams of coal, the coal itself in immediate contact with the igneous rock has changed to coke through the agency of contact metamorphism.

* U. S. Geol. Surv., Bull. No. 255.

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